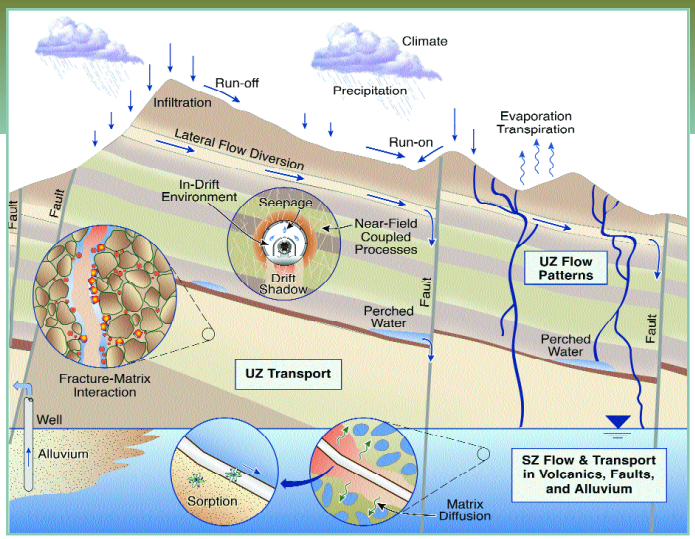
Research Program

Nuclear Waste



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Geological isolation of spent nuclear fuels and high-level radioactive waste is currently the preferred means of disposal for many countries worldwide. The role of ESD's Nuclear Waste Program (NWP) is to assist the U.S. Department of Energy, the United States, and other countries in achieving the safe disposal of high-level radioactive waste—by means of high-quality scientific analyses that encompass modeling, laboratory and field experiments, and technology development. The majority of research within NWP relates to Yucca Mountain, the proposed site for the permanent storage of high-level nuclear waste in the USA; although NWP has also collaborated on nuclear-waste disposal issues with countries such as Japan, Finland, Switzerland, Spain, Sweden, and China.

The geologic repository program in the United States is at a point where the Department of Energy (DOE) is close to completing the license application for repository construction at Yucca Mountain to the Nuclear Regulatory Commission. If the license application process proceeds as planned by DOE, the Yucca Mountain repository is scheduled to start accepting waste in 2010. The safe performance of a high-level nuclear waste repository hinges on the multiple-barrier concept—namely, that the natural system and the engineered system would each contribute significantly to prevent radionuclides from leaving the repository and entering the biosphere. The proposed repository at Yucca Mountain, consisting primarily of fractured volcanic tuffs that vary in degree of welding, will be located about 350 m below ground surface within a thick unsaturated zone (UZ) above the water table. Over the last decade, NWP's work at Yucca Mountain consists of site characterization studies aimed at understanding the barrier function of the UZ, through field testing in an underground facility, an 8 km long underground tunnel known as the Exploratory Studies Facility (ESF). Complex numerical models have also been developed to simulate and understand the relevant processes related to multiphase, nonisothermal flow and transport through the UZ. Some of the key questions addressed by NWP scientists include:

- How much water percolates through the UZ to the repository at Yucca Mountain?
- What fraction of the water flows in fractures and what fraction flows through the rock matrix blocks?
- How much of this water will seep into the emplacement drifts (tunnels)?
- How will the radionuclide migration from the repository to the water table be retarded?
- How will coupled TH (thermal-hydrological), THC (thermal-hydrological-chemical), and THM (thermal-hydrological-mechanical) processes affect flow and transport?

Apart from the above studies that pertain to the barrier function of the UZ and its contribution to the safety case of the license application, NWP scientists have also conducted research under a new Office of Science and Technology International Program (OST&I) within the DOE Office of Civilian Radioactive Waste Management (OCRWM). Distinct from, but in parallel to, the licensing effort at the Yucca Mountain, the role of OST&I is to advance technologies not previously considered, to identify new or substantially revised scientific methods or tools that would provide a better understanding of the repository environment. The OST&I program is

a well-integrated, focused research and technology program that aims to reduce cost, reduce uncertainty, enhance performance, develop new technologies, and overall greatly enhance the repository system, its performance, and its defensibility during and beyond the license application defense. The OST&I program funds proposals from national laboratories and universities and is currently organized into four Targeted Thrust areas: (1) Source Term, (2) Material Performance, (3) Radionuclide Getters, and (4) Natural Barriers.

Berkeley Lab's Earth Sciences Division is the Lead for the Natural Barriers Thrust. The goal for the Natural Barriers Thrust is to focus on research that would provide the essential scientific basis and demonstration of large contributions to repository performance by the unsaturated and saturated volcanic rocks at Yucca Mountain. The enhanced understanding of the different processes in the natural system would lead to reduction of uncertainty and obviate the need for overconservatism. NWP scientists are conducting studies pertaining to:

- In-drift processes, integrating thermal-hydrologic-chemical-transport (THCM) models that simultaneously consider source term, corrosion, and the hydrological-chemical environment around waste package processes and conditions—and synthesize these complex processes into transparent, realistic, and defensible process models
- Near-drift processes, such as found in laboratory, field, and analogue studies to confirm the drift shadow concept, and the fact that it will lead to a large delay and sorption of radionuclides in the near-drift region
- Processes and conditions that will retard or mitigate flow and transport through the unsaturated and saturated volcanic rocks

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